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ADVISORY CIRCULAR

DEPARTMENT OF TRANSPORTATION
Federal Aviation Administration
Washington, D.C.

FAR GUIDANCE MATERIAL

Subject: TRANSPORT CATEGORY AIRPLANES CABIN OZONE CONCENTRATIONS

1. PURPOSE. This advisory circular provides guidance concerning acceptable means, but not the only means, for an air carrier to demonstrate compliance with the maximum permissible cabin ozone (O_3) concentrations established by Section 121.578 of the Federal Aviation Regulations (FAR).

2. RELATED FAR SECTIONS. This advisory circular is also related to Section 25.832.

3. RELATED READING MATERIAL. Additional information on ozone concentrations may be found in the following documents:

a. Federal Aviation Administration (FAA) documents:

(1) Simultaneous Cabin and Ambient Ozone Measurements on Two Boeing 747 Airplanes, Volume I - Report Number FAA-EE-79-05 (NTIS Accession Number ADA 079 114).

(2) Guidelines For Flight Planning During Periods of High Ozone Occurrence - Report Number FAA-EQ-78-03 (NTIS Accession Number ADA 050 988).

(3) Effects of Ozone on Exercising and Sedentary Adult Men and Women Representative of the Flight Attendant Population - Report Number FAA-AM-79-20 (NTIS Accession Number ADA 080 045).

(4) Ozone Concentration By Latitude, Altitude, and Month, Near 80° West - Report Number FAA-AEQ-77-13 (NTIS Accession Number ADA 046 956).

Copies of these reports may be purchased from the National Technical Information Service; Springfield, Virginia 22161.

b. Federal Aviation Administration Advisory Circular 00-52, Ozone Irritation During High Altitude Flight. Copies of this advisory circular may be obtained free of charge from the U.S. Department of Transportation; Publications Section M-443.1, Washington, D.C. 20590.

Initiated by: AFO-260

c. National Aeronautics and Space Administration Documents:

(1) Ozone Contamination in Aircraft Cabins - Report Number NASA CP-2066 (NTIS Accession Number N 79-21021).

(2) Procedures for Estimating the Frequency of Commercial Airline Flights Encountering High Cabin Ozone Fields - Report Number NASA TP-1560 (NTIS Accession Number N 79-33171).

Copies of these reports may be obtained from the National Technical Information Service; Springfield, Virginia 22161.

d. National Primary and Secondary Ambient Air Quality Standards, Title 40, Chapter I, Subchapter C, Part 50 - Environmental Protection Agency final rulemaking, Federal Register, Volume 44, Number 28, Page 8202 - Thursday, February 8, 1979.

4. BACKGROUND.

a. Natural ozone is formed primarily above the tropopause in the upper atmosphere as a result of the action of ultraviolet light on oxygen molecules. The amount and distribution of natural ozone in the atmosphere varies with latitude, altitude, season, and weather conditions. [See paragraph 3a(2).] The highest concentrations in the northern hemisphere are generally found at high altitude over high latitude locations during the winter and spring.

b. In late 1976, complaints were received from crewmembers on high altitude, high latitude, long range flights which described discomforts such as eye irritations, coughing, nose irritations and chest pains. Subsequent research determined that some of these symptoms could be attributed to ozone in the aircraft cabin. Significant ozone concentrations were occasionally measured in the cabin of aircraft on high latitude, high altitude flights and research studies conducted in an altitude chamber demonstrated that significant ozone concentrations may produce similar symptoms in some persons.

c. Part 121 of the FAR has been amended so that a certificate holder may not operate a transport category airplane above flight level 180 unless it has successfully demonstrated to the Administrator that the concentration of ozone inside the cabin will not exceed .25 parts per million by volume, sea level equivalent, at any time; and time-weighted value of .1 part per million by volume, sea level equivalent, for scheduled flight segments of more than 4 hours. Compliance with these requirements should be shown by analysis and/or tests based either on airplane operational procedures and performance limitations or the certificate holder's operations. The analysis or tests must show either (1) that atmospheric ozone statistics indicate, with a statistical confidence of at least 84 percent, that at the altitudes and locations at which the airplane will be operated that the permissible levels of cabin ozone concentrations will not be exceeded; or (2) that the airplane ventilation systems, including any ozone control equipment, will maintain the cabin ozone concentrations at or below the permissible levels. Acceptable means of conducting the required analysis or tests are discussed in paragraph 5 of this advisory circular.

d. It is expected that research into the physiological effects of ozone and effective methods for its control will continue to provide a greater understanding of its effects on persons and will increasingly provide more effective methods to eliminate excessive ozone quantities. Nevertheless, current technology is adequate to eliminate excessive levels of ozone in aircraft cabins. Filters and catalytic converters for reducing cabin ozone concentrations are available which can be installed on affected aircraft types. However, several additional methods exist which may, in certain cases, maintain cabin ozone concentrations at or below the maximum permissible levels. An air carrier may use any of the methods contained in this advisory circular if the analysis or tests conducted show that the method(s) chosen are effective.

e. Since each of the various methods has certain beneficial aspects, one method is not favored over any other. However, the FAA intends to conduct inflight spot checks to ensure compliance with the standards.

5. MEANS OF COMPLIANCE.

a. Acceptable means of demonstrating compliance includes any one or a combination of the following:

(1) A statistical analysis which is based on acceptable atmospheric ozone statistics, the types of aircraft flown, and the route structure used in the air carrier's operation.

(2) A statistical analysis which is based on actual measurements of cabin ozone concentrations for the types of aircraft operated and obtained over routes or areas representative of the air carrier's route structure.

(3) Modifications to the aircraft by an air carrier, under a Supplemental Type Certificate (STC), FAA Form 337 approval, or an engineering order/authorization to comply with a manufacturers approved service bulletin, which reduces the ozone concentrations to acceptable levels in the aircraft cabins.

(4) Modifications to the aircraft by the manufacturer or design changes which reduce cabin ozone levels to acceptable levels.

(5) Modifications to operational procedures, such as the use of a higher stage bleed air or the use of recirculation controls, to reduce ozone to acceptable levels.

(6) Flight planning procedures to adjust the flight altitude and/or route of flight to reduce cabin ozone to acceptable levels.

b. Examples of the specific means or combination of means which may be used by an air carrier to demonstrate compliance are discussed in detail in paragraphs 6, 7, and 8 of this advisory circular.

6. STATISTICAL ANALYSIS.

a. If the carrier elects to use statistical analysis to demonstrate compliance, the method used should demonstrate with a statistical confidence level of 84 percent that the cabin ozone levels will be within acceptable limits.

b. The ozone data base used in the analysis should include sufficient data to demonstrate compliance within the area of operation on a month-to-month basis. Any statistical analysis should be based on acceptable atmospheric ozone statistics, actual inflight measurements, or a combination of both.

c. Acceptable atmospheric ozone statistics are contained in the publications listed in paragraph 3a(2) and 3a(4). If actual inflight measurements are used, they should provide a sufficient data base to establish the required statistical confidence level and contain monthly altitude, latitude and longitude resolution elements equivalent to those in Appendix A of the publication listed in paragraph 3a(2) for the type(s) of airplanes flown and the operations conducted. Additionally, actual inflight cabin ozone measurements should be obtained with equipment which has been periodically calibrated and maintained in accordance with approved Environmental Protection Agency (EPA) procedures.

d. One of the elements which should be considered in a statistical analysis based on acceptable ambient ozone statistics is the ozone dissociation (destruction) rate for the environmental control system installed in a particular type of airplane. This factor determines the percentage of the ambient ozone which is ultimately introduced into the cabin environment. The ozone dissociation rate is applied to the ambient ozone statistics to determine the cabin ozone statistics for that flight altitude, time and location.

e. Normally, the dissociation rate has been determined by simultaneous inflight measurements of ambient and cabin ozone levels. However, other methods, such as laboratory measurements or an engineering analysis, may be used to establish the dissociation rate for a particular environmental control system if these methods are shown to be accurate and reliable.

f. In cases where the dissociation rate is unknown, a statistical analysis may still be used to show compliance. In this case, it may be necessary to assume that the rate is zero and the cabin levels are equal to the ambient levels.

g. Statistical analysis required by this advisory circular may be obtained from pools of data formed by cooperation between operators and manufacturers. Data to determine the cabin ambient ozone dissociation (destruction) rate for the statistical analysis approach of Appendix 1 of this advisory circular may be accepted if it comes from other operators of the same type of aircraft with the same cabin air handling systems, or is otherwise shown to be appropriate. Cabin ozone data from these aircraft may also be accepted for demonstrating compliance with the permissible ozone level if the data are taken in the same geographic area.

h. Acceptable means of conducting this statistical analysis are contained in Appendix 1 of this advisory circular and the publication listed in paragraph 3c(2). However, either of these methods should use acceptable ozone statistics (see Appendix 2).

7. AIRCRAFT DESIGN CHANGES/MODIFICATIONS AND EQUIPMENT INSTALLATION.

a. Design changes/modifications may be used to demonstrate compliance if analysis and/or tests show that these methods reduce the cabin ozone concentrations to acceptable levels for each type of aircraft flown and each operation conducted. The tests, if required, may be conducted in a laboratory, inflight, or a combination of both. A statistical analysis based on acceptable ozone statistics may also be used to demonstrate that the ozone dissociation rate for the device(s) installed will reduce the cabin ozone to acceptable levels.

b. Once the ozone dissociation rate has been established for a particular device, the potential maximum cabin ozone concentration and the time-weighted averages, if appropriate, are determined by applying the dissociation rate to the ambient ozone concentrations contained in the statistical analysis. The dissociation rate should be high enough to demonstrate compliance on a month-by-month basis within the area of operation.

c. In any case, the air carrier should demonstrate to the Administrator that the design changes/modifications and/or the equipment installed will reduce the cabin ozone concentrations to acceptable levels in each type of aircraft used and for each route flown by its aircraft. The ozone dissociation equipment, if installed, should be included in the air carrier's approved maintenance program and should be inspected, repaired and/or replaced in accordance with approved procedures. The initial service life of the ozone dissociation equipment should be established through analysis and tests.

d. Examples of a procedure for demonstrating compliance after installation of equipment with a known ozone dissociation rate are contained in Appendix 1 of this advisory circular.

8. OPERATIONAL AND/OR FLIGHT PLANNING PROCEDURES.

a. If an air carrier chooses to adopt operational or flight planning procedures to demonstrate compliance, these procedures should be shown to reduce cabin ozone concentrations to acceptable levels for each type of aircraft used and for each route or area flown by these aircraft.

b. The required analysis and/or tests should use inflight measurements and/or statistical data from acceptable ozone statistics to show that the operational and/or flight planning procedure to be used will reduce the cabin ozone concentrations to acceptable levels. The ozone dissociation (destruction) rate for the environmental control system installed in the particular type(s) of airplanes used by the air carrier should be considered when conducting a statistical analysis. This factor determines the percentage of the ambient ozone which is ultimately introduced into the cabin environment. If the dissociation rate is unknown, it may be neccesary to assume that the rate is zero and the cabin levels are equal to the ambient levels.

c. In one method, the location of high ozone concentrations would be predicted and flight planning procedures would route the flight to reduce the cabin ozone to acceptable levels. Similar methods may be used to determine when operational procedures, such as using high stage bleed air, or using recirculation controls, are

necessary to dissociate sufficient ozone to obtain compliance. However, data from inflight measurements are necessary to demonstrate that these procedures are effective. This is due to the difficulty of reliably predicting ozone concentrations at normal flight altitudes. Furthermore, these data should show that the techniques used to predict ozone concentration levels for a particular flight indicate that there is a statistical confidence level of 84 percent that the flight will not exceed the permissible maximum concentrations at any point along the route of flight.

d. An alternate method would be to restrict the flight altitude on certain flights or segments of flights to achieve compliance. Acceptable ozone statistics should be used to conduct an analysis which shows that the flight altitude(s) authorized for a particular route or area of operation will maintain the cabin ozone concentration within acceptable limits. In some cases, these restrictions may be necessary only during certain months. An example of such a statistical analysis to demonstrate compliance is contained in Appendix 1 of this advisory circular.

e. In any case, sufficient data should be provided to show the Administrator that these procedures are reliable and effective in reducing cabin ozone to acceptable levels for each type of aircraft and each route or area flown by these aircraft.

9. OPERATIONAL APPROVAL.

a. The application for approval of the method(s) proposed by the air carrier to reduce cabin ozone to acceptable levels should be submitted to the FAA certificate holding office for review and approval at least 30 days prior to using the proposed method(s) in air carrier service. This application should contain any pertinent airworthiness approvals, as well as the necessary supporting data, and the proposed amendments to the operations specifications.

b. The supporting data should show that the method(s) to be used by the air carrier will reduce cabin ozone concentrations to acceptable levels for each type of aircraft used and each route or area flown by those aircraft. The operations specifications should reflect any operational restrictions necessary to achieve compliance.

c. If the air carrier demonstrates that the method(s) to be used are effective, approval should be granted by amendment to the operations specifications. Approval in the operations specifications may be granted by area of operation, by individual routes, or a combination of both. The approval should include the restrictions (i.e., maximum flight altitude, operational procedures, aircraft modifications) necessary to achieve compliance. The restrictions should be applicable to the types of aircraft operated or types of operations conducted, or both.

10. REQUESTS FOR DEVIATION FROM THE COMPLIANCE PERIOD.

a. The FAA has determined that the 12-month period provided for air carriers to comply with this rule is reasonable and adequate. However, the new Section 121.578 allows a certificate holder to obtain an authorization to deviate from these requirements by an amendment to its operations specifications, if it shows that due to circumstances beyond its control or to unreasonable economic burden it cannot comply for a specific period of time, and submits a plan acceptable to the

Administrator to effect compliance to the extent possible. A deviation can be authorized in circumstances such as equipment delivery delays or short-term use of aircraft, when the certificate holder shows that, through flight planning or other means, it attempts to avoid areas of cabin ozone concentrations above the limits given in the rule.

b. Any request for deviation should state the reasons why compliance cannot be demonstrated during the time period and why these factors are beyond the control of the air carrier. The request should also contain a compliance schedule and a plan to effect compliance to the extent possible which are acceptable to the Administrator.

c. The request for deviation should be submitted to the FAA certificate-holding office at least 60 days before the compliance date of February 20, 1981, stated in Section 121.578 of the FAR.

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